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Examining the Sensitivity and Specificity of two screening instruments: odontogenic or temporomandibular disorder pain?

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Examining the Sensitivity and Specificity of two screening instruments: odontogenic or temporomandibular disorder pain?

Abstract

Introduction: Two orofacial pains that are clinically important to distinguish are odontogenic pain and temporomandibular disorders (TMD) pain. The aim of this study was to determine the sensitivity and specificity of two screening instruments in distinguishing between patients with these types of pain.

Methods: A convenience sample of patients seeking care at an Endodontic clinic and an Orofacial Pain clinic were recruited. The 14-item Dental Pain Questionnaire (DePaQ) was used to screen for odontogenic pain and the 6-item TMD-screener was used to screen for TMD pain. Sensitivity and specificity calculations, with 95% confidence intervals (CI), were performed for both instruments and thresholds/acceptability/performance was assessed using published guidelines.

Results: Thirty-four patients with odontogenic pain and 37 patients with TMD pain were included in this study. The sensitivity of the DePaQ was 0.85 (95%CI: 0.69-0.95) and specificity was 0.11 (95%CI: 0.03-0.25). The sensitivity of the TMD screener was 0.92 (95%CI: 0.78-0.98) and specificity was 0.59 (95%CI: 0.41-0.75). The point estimates, a single value used to estimate the population parameter, for both the DePaQ and TMD screener were "acceptable" in identifying patients who had the pain condition in question (*i.e.*, sensitivity), while the point estimate for appropriately identifying patients who did not have the pain condition when they did not have it (*i.e.*, specificity) was "non-acceptable" for both.

Conclusion: The DePaQ and the TMD Screener lack diagnostic accuracy for differentiating TMD from odontogenic tooth pain without adjunctive (clinical) investigation(s) or examination. The TMD screener, however, has high sensitivity for identifying true positives *i.e.* TMD pain, and would therefore be useful as a screening instrument when one can exclude odontogenic pain definitively on clinical and radiographical grounds for instance in endodontic practices. In this study the negative predictive value was also high in the TMD screener and therefore we can trust a negative result: that is when the TMD screener is negative we can be fairly certain the pain diagnosis is not TMD and rule out TMD.

Introduction

Tooth pain is the most prevalent pain complaint in the orofacial region, with a 12% prevalence (1). The majority of tooth pain is of odontogenic origin (2), that is inflammation in and around the tooth and this pain is one of the most common reasons patients seek dental care (3-5). The term odontogenic pain encompasses a number of potential diagnoses: symptomatic irreversible pulpitis as a pulpal diagnosis; symptomatic apical periodontitis and acute apical abscess as apical diagnoses (6).

A complaint of "tooth" pain may in fact have a non-odontogenic origin as a result of referred pain from other structures. For example temporomandibular disorders (TMD) are known to refer pain to the dentoalveolar structures (7, 8). From the patients that visit the dental office because of “tooth” pain, a sizeable proportion (12-50%), have a non-odontogenic or mixed origin for their pain (7, 9-11). The most common non-odontogenic reason for “tooth” pain is pain related to a TMD, which arises from muscle of mastication, temporomandibular joints, and/or associated structures (11-13).

As odontogenic pain is common it is something dentists are experienced in diagnosing and managing. Occasionally, despite being an odontogenic complaint, tests for dental pathology are negative and dentists need to consider non-odontogenic reasons for the pain. Having a brief valid screening instrument to aid in identifying the most common non-odontogenic reason for “tooth” pain may be helpful in identifying such patients within regular dental practice. Therefore, the aim of this study was to examine the sensitivity and specificity of two screening questionnaires, one designed for odontogenic pain (DePaQ) and one for TMD related pain (TMD screener), in patients

experiencing pain of either odontogenic or TMD origin. The secondary aim of this study was to explore the performance of the screening questions in subsets of patients, those where TMD pain is referred to the dentoalveolar region and presents as “tooth” pain. This assessment is to explore whether this subgroup performs differently compared to patients experiencing regular TMD pain.

Methods

This cross-sectional study is derived from data collected within a parent study designed to explore item selection for the development of a Persistent Dentoalveolar Pain disorder (PDAP) screening questionnaire. Ethics approval from the University of Minnesota was obtained and all the participants provided informed consent prior to their participation. The Standards for Reporting Diagnostic accuracy studies (STARD) criteria were used for reporting results (14).

Participants

Recruitments of patients were performed by board certified Orofacial Pain practitioners and a board certified Endodontist. TMD pain patients were recruited from the TMD and Orofacial Pain Clinic in the School of Dentistry at the University of Minnesota, Minneapolis, Minnesota. Odontogenic pain patients were recruited in a private endodontic practice, The Dental Specialists, within the Twin Cities area. A convenience sample of these two groups of patients was collected. Some patients with TMD pain perceived their pain in the jaw and face, while others perceived their pain in a tooth/alveolus, as referred from other structures. These differences in the two subgroups will be covered in greater detail below.

Enrollment criteria

The following criteria were used to select patients for this study.

Inclusion Criteria

Odontogenic pain sample: Patients diagnosed with symptomatic irreversible pulpitis, symptomatic apical periodontitis, and/or symptomatic apical abscess following American Association of Endodontists diagnostic criteria (15, 16).

TMD pain sample: Patients with diagnosis of TMD pain, including myalgia, myofascial pain with referral or arthralgia following the diagnostic criteria for TMD (DC/TMD) (17). Among the TMD sample, patients presenting with referred pain to surrounding areas (myofascial pain with referral) were accepted. This meant within the TMD pain sample there were two subgroups one with referral of pain to the dentoalveolar region, as described by Wright (12), and one without referral to this region. These subgroups were purposively selected due to the increased potential for diagnostic confusion.

Patients included in the sample had to be: seeking treatment for their painful condition in one of the clinics of the study; aged 18 years old and older; conversant in English.

Exclusion Criteria:

Patients were excluded from the study if they presented with both an odontogenic and a TMD pain diagnosis, had another comorbid orofacial pain diagnosis, had a history of traumatic injuries to the orofacial region, had a major systemic illness related to altered pain sensitivity such as rheumatoid arthritis, fibromyalgia and other widespread bodily pain conditions, had a history of TMJ surgery or inter-articular steroid injection, were unable to give informed consent, or had been involved in a prior qualitative research study to generate questionnaire items for the parent study (18, 19).

Sample Size

The number of patients per pain group was calculated to be 35 per group and slight over-recruitment was intended to allow for a low expected dropout rate.

Screening questionnaires used

Dental pain screening questionnaire

The DePaQ (Appendix 1) was used as the instrument to detect patients with odontogenic pain given its widespread usage in the literature (20-23). It is a 14-item questionnaire developed in the United Kingdom, designed to differentiate three groups of odontogenic tooth pain:

- Group A: Irreversible pulpitis and acute apical periodontitis.
- Group B: Reversible pulpitis and dentine hypersensitivity.
- Group C: Pericoronitis.

The item generation study of this questionnaire was developed within a sample of 313 patients, where just over 50% were male. The sample consisted of Group A patients-35%, Group B-32%, and Group C-18%. Its original validation study (23) demonstrated sensitivity (95% CI) of: 80% (71 to 87%) for Group A, 85% (62 to 97%) for Group B and 59% (36 to 80%) for Group C; specificity of 83% (69 to 93%), 89% (83 to 94%) and 90% (84 to 95%) respectively.

TMD screening questionnaire

The TMD screener (Appendix 2) was developed as a self-report instrument in screening patients for pain-related TMD (24). It was designed in a long (six-item) and short (three-item) versions using psychometric methods for item selection, and evaluated for validity among 504 participants. It compared pain-related TMD versus healthy controls; versus non-painful TMD; and versus headaches. Among the results, in all the groups and both questionnaires, the sensitivity was 99%, where specificity was 97% in the long version and slightly lower at 95% in the short version. In our study we focused on assessing the long version, which is expected to perform best, and presented data on the short version for completeness.

Data management and statistical analyses

Data entry was performed by two of the participating clinicians and was cross-checked for accuracy by a third investigator. Data were managed using the spreadsheet software Microsoft Excel (Microsoft Excel 2010 for PC: Microsoft Corporation) and all analyses were performed using the statistical software package STATA (Stata Statistical Software: V12 for Mac. College Station, TX: StataCorp LP).

The data were analyzed comparing all patients with known odontogenic pain with all patients with known TMD pain group using the two questionnaires. This was contrasted using two by two tables. Four subgroup analyses were performed, depending on the site where the pain was felt. The analyses were as follows:

- Aim 1.0. Determine the sensitivity and specificity of the DePaQ for identifying all patients with odontogenic pain versus all patients with TMD pain as controls

- Subaim 1.1. Determine the sensitivity and specificity of the DePaQ for identifying all patients with odontogenic pain versus patients with TMD pain, excluding TMD pain referred to teeth as controls.
- Subaim 1.2. Determine the sensitivity and specificity of the DePaQ for identifying all patients with odontogenic pain versus patients with TMD pain referred to teeth only as controls.

– Aim 2.0. Determine the sensitivity and specificity of the TMD screening questionnaire for identifying all patients with TMD pain versus odontogenic pain patients as controls.
  - Subaim 2.1. Determine the sensitivity and specificity of the TMD screening questionnaire for identifying patients with TMD pain, excluding TMD pain referred to teeth, versus odontogenic pain patients as controls.
  - Subaim 2.2. Determine the sensitivity and specificity of the TMD screening questionnaire for identifying patients with TMD pain referred to teeth only versus odontogenic pain patients as controls.

Results are presented as point-estimates, a single value used to estimate the population parameter, for the sensitivity and specificity of the questionnaires for each comparison with 95% confidence intervals presented to demonstrate the level of precision these calculations offer.

Levels of diagnostic accuracy were assessed using sensitivity and specificity estimates described by Dworkin and LeResche (acceptable sensitivity=70% and acceptable specificity=95%)(25).

Results

Description of patients

A total of 82 patients participated in this study but 11 of them were excluded due to: volume of missing data in either of the screening instruments (n=5; of which 4 were TMD) and diagnosis of comorbid TMD with odontogenic pain (n=6). The demographics of the patients enrolled are presented in Table 1.

Of the 71 patients included, 34 (47%) of them had odontogenic pain: 5 (15%) with symptomatic irreversible pulpitis only, 17 (50%) with symptomatic apical periodontitis only, 6 (18%) with acute apical abscess, and 6 (18%) with symptomatic irreversible pulpitis and symptomatic apical periodontitis.

Thirty-seven patients were recruited to the TMD pain group: 17 (46%) with myofascial pain, 2 (5%) with arthralgia, and 18 (49%) with myofascial pain and concomitant arthralgia. Figure 1 demonstrates the subdivision of the TMD pain group into pain referred to dentoalveolar structures (n=12 within TMD pain group).

Diagnostic accuracy of questionnaires

Using the DePaQ as the screening instrument, to discriminate between odontogenic pain group versus the whole TMD pain group, the sensitivity obtained was 0.85 (95%CI=0.69-0.95), and the specificity was at 0.11 (95%CI=0.03-0.25). When the TMD pain sample was divided in the two subgroups depending on whether TMD pain was referred to teeth or not, in both cases sensitivity remained the same and only specificity

changed. When comparing odontogenic pain versus TMD pain not referring to teeth, specificity increased to 0.12 (95% CI=0.03-0.31). When comparing odontogenic pain versus TMD pain referring to teeth only, specificity decreased to 0.08 (95% CI=0.002-0.38). Table 2 shows additional details.

When the 6-item TMD screener was the questionnaire used to compare the odontogenic pain group versus the whole TMD pain group, it showed a sensitivity of 0.92 (95%CI=0.78-0.98), and specificity of 0.59 (95%CI=0.41-0.75). When the TMD pain sample was divided in the two subgroups where TMD pain was referred to teeth or not, in both cases specificity remained the same and only sensitivity changed. When comparing odontogenic pain versus TMD pain not referring to teeth, the confidence interval widened 0.92 (95% CI=0.74 to 0.99), while when comparing odontogenic pain versus TMD pain referring to teeth only, sensitivity and specificity were 0.92 (95%CI:0.61-1.00) and 0.59 (95%CI:0.41-0.75) respectively. Table 2 shows additional details. When the 3-item TMD screener was used to compare the odontogenic pain group versus the whole TMD pain group, it showed a sensitivity of 0.99 (95%CI=0.86-0.99), and specificity of 0.22 (95%CI=0.10-0.38).

Discussion

The purpose of this study was to test whether either screening questionnaire, one used to identify odontogenic pain and one used to identify TMD pain, can adequately separate patients with these orofacial pain conditions. The results indicate that both questionnaires, the DePaQ and the TMD screener, have an acceptable sensitivity whilst the specificity is unacceptable for both screening questionnaires according to the criteria used(25). This means that DePaQ will identify those patients that have odontogenic pain most of the time, 85%, when they have odontogenic pain and the TMD screener will identify those patients that have TMD pain most of the time, 92%. Nevertheless the questionnaires perform less well in identifying patients as not having the disorder when they do not have it. The DePaQ, with a specificity of 11% will classify 89% of the patients with TMD as patients having odontogenic pain. Such a high false positive rate limits this questionnaire's use in populations with both TMD pain and/or odontogenic pain. The 6-item TMD screener, with a specificity of 59%, will classify 41% of the patients with odontogenic pain as having TMD pain; while the 3-item TMD screener, with a specificity of 22%, will classify 78% of the patients with odontogenic pain as having TMD pain. Furthermore, the TMD screener and the DePaQ do not seem to be influenced by the site of pain because subset analyses yielded very similar sensitivity and specificity results when patients with TMD pain perceived to be of tooth origin only were compared to TMD pain patients perceived to be in the jaw. This is encouraging because some TMD pain patients do not seem able to distinguish between different locations of

their TMD pain(26) and dentists have been reported to misinterpret TMD pain perceived as "tooth" pain as being odontogenic in origin(8).

Comparison of patient population with other studies

It is difficult to compare our enrolled patients with those enrolled with the studies used to develop the questionnaires because the description of the populations used in these studies is sparse. Verifying the population as "typical" for TMD and odontogenic pain would help to understand the results. For comparison purposes, the characteristics of our sample of patients seems to be similar to larger studies seeking to have representative patients with TMD(27) and odontogenic pain(28) is interesting (compare Table 1 with Table 3, which depicts the characteristics of the patients within each of these two studies). Given the similar sociodemographic profile of our sample of patients with these other studies, it is likely we have examined the instruments in a fairly representative sample of patients.

Comparison of diagnostic accuracy with previous studies

The DePaQ demonstrated acceptable sensitivity at 0.85 and this was comparable to its results in its validation studies(23). The specificity results in our study, however, showed an unacceptable specificity, 0.11 which was substantially smaller than that identified in the validation studies (0.83). The DePaQ is widely recommended as a screening test for odontogenic pain, however, the assessment of referred pain from other sources felt in the teeth was neglected when the questionnaire was developed. In fact, previous studies only

compared different types of tooth pain, and did not compare these to other pains in the face/head that could confuse patient and practitioner when describing/giving a diagnosis.

The DePaQ was developed to classify patients into three different groups, depending on their condition, thereby attempting to facilitate the assessment of dental treatment needs. It has been seen in this study that there was a high probability of false positive results, in case of a non odontogenic origin of the pain, potentially resulting in a risk of mistreatment.

The use of the DePaQ as a screening instrument for patients complaining of “tooth” pain may cause confusion to patients and practitioners when it scores positive for odontogenic pain and teeth are not the cause of the pain. Given the low specificity score, this questionnaire is not recommended for use to differentiate between odontogenic pain and TMD pain.

The 6-item TMD screener scored 0.92 in sensitivity, slightly less than in the development and validation study, but still acceptable. This slight difference is expected because the score is expected to decrease when the questionnaire is tested in a different population from one that was used to derive it. During the original development of the TMD screener, odontogenic pain patients were included(24), which is an expected source of diagnostic confusion and likely the reason why our observed specificity of 59% was less than their values ranging from 95% to 98%(24). The specificity is especially reduced, down to 22%, when the 3-item version of the TMD screener is used; which suggests that the longer version is preferred when it is to be used with such patient populations.

Considerations regarding prevalence and clinical usefulness

We have interpreted sensitivity and specificity because these measures of diagnostic test accuracy are assumed to be relatively stable across populations. However, the clinical usefulness of the test in a particular setting is determined through its predictive values and they depend on the prevalence of the disease. For example, for a prevalence of TMD in this study cohort of 52% (37/71 patients), TMD screener's PPVs was 71%, indicating that 71 of 100 patients with a positive test result do indeed have the disease. The confidence interval for the PPV for the TMD screener also indicated that a result of only 56 of 100 patients was also compatible with our study findings. In settings with lower prevalence of the disease, PPV would be even lower, indicating that a positive test result cannot be trusted. Only NPV was high for the TMD screener, indicating that a negative test result can be trusted.

Items analysis as potential to improve diagnostic test accuracy

Performing an item analysis can help identify the discriminative properties of individual questions within the screeners. Table 4 presents the mean answers to the DePaQ and to the TMD screener for each item, as well as Fischer's coefficients for each question for a positive result for odontogenic pain in the DePaQ. The results of the item analysis are relevant in three questions:

1. Question number 2 in the DePaQ relating to duration of the pain had a mean(SD) result of 2.3(1) for odontogenic pain and 4.2(0.9) for TMD pain not referring to

teeth, and 4.2(1.1) for TMD pain referring to teeth. This means that the way this question is formulated helps to separate odontogenic pain from TMD pain.

2. Question number 1 in the TMD screener, relating to the duration of the pain, had results for the three groups that were similar. The mean scores (SD) were 1.1(0.8) for odontogenic pain, 1.4(0.5) for TMD pain not referring to teeth and 1.3(0.6) for TMD pain referring to teeth. This shows that the wording of this question is not sufficient to separate these different sources of pain.
3. Question number 3 in the TMD screener, relating to having pain when chewing hard and tough food, had a mean score(SD) of 0.8(0.4) for odontogenic pain, 1(0.2) for TMD pain not referring to teeth, and 1(0) for TMD pain referring to teeth. This indicates that all the groups have pain when chewing, and that odontogenic pain patients cannot differentiate between originating from muscle of mastication and/or TMJ verses teeth.

Together, these findings indicate that the TMD screener may be used as an adjunct, but not sufficient, for differentiating TMD pain from odontogenic pain.

Limitations

Our sample size was limited and therefore confidence intervals for diagnostic accuracy measures' point estimates were wide. Larger subgroups, such as TMD pain referred to teeth, would, therefore, be helpful in adding confidence that what we observed is not a spurious finding due to the clinic setting from which these patients were recruited. Furthermore having a third group that had both odontogenic pain and TMD pain would be helpful in elucidating how these screening questionnaires performed in the

presence of comorbid pain conditions. It is also conceivable that patients with anterior tooth pain verses posterior tooth pain may answer questions differently as might patients with primarily a pulpal diagnosis for their pain, such as symptomatic irreversible pulpitis, as opposed to patients with apical diagnoses for their pain, such as necrotic pulp and symptomatic apical periodontitis (15).

Conclusion

Both the DePaQ and the TMD screener have acceptable sensitivity, but unacceptable specificity. The extremely low result in the specificity in the DePaQ and 3-item TMD screener means that they are not suitable for use for diagnostic purposes in populations that are known to have TMD pain because it will misdiagnose people with odontogenic pain as having TMD. For epidemiological studies designed to gauge the magnitude of tooth pain prevalence, these questionnaires can still be used because the known error rates can be used to recalculate the prevalence. A word of caution for this should be given because there is considerable uncertainty in the estimate, due to the large confidence intervals, and therefore this approach may have limited utility. The 6-item TMD screener, because it has modest specificity and excellent sensitivity, has the best potential for use in distinguishing people with odontogenic pain from TMD pain in clinical settings where TMD prevalence is not very low and for use in epidemiological studies.

References

1. Lipton JA, Ship JA, Larach-Robinson D. Estimated prevalence and distribution of reported orofacial pain in the United States. Journal of the American Dental Association (1939). 1993 Oct;124:115-21.

2. Horst OV, Cunha-Cruz J, Zhou L, Manning W, Mancl L, DeRouen TA. Prevalence of pain in the orofacial regions in patients visiting general dentists in the Northwest Practice-Based Research Collaborative in Evidence-Based Dentistry Research Network. J Am Dent Assoc. 2015 Oct;146:721,8.e3.

3. Armfield JM, Stewart JF, Spencer AJ. The vicious cycle of dental fear: Exploring the interplay between oral health, service utilization and dental fear. BMC Oral Health. 2007 Jan 14;7:1.

4. Maggirias J, Locker D. Psychological factors and perceptions of pain associated with dental treatment. Community Dent Oral Epidemiol. 2002 Apr;30: 151-9.

5. Sharav Y, Leviner E, Tzukert A, McGrath PA. The spatial distribution, intensity and unpleasantness of acute dental pain. Pain. 1984 Dec;20:363-70.

6. McClannahan SB, Baisden MK, Bowles WR. Endodontic diagnostic terminology update. Northwest Dent. 2011 Sep-Oct;90:25-7.

7. Yatani H, Komiyama O, Matsuka Y, Wajima K, Muraoka W, Ikawa M, et al. Systematic review and recommendations for nonodontogenic toothache. J Oral Rehabil. 2014 Nov;41:843-52.

8. Mattscheck D, Law A, Nixdorf D. Diagnosis of nonodontogenic toothache. In: Cohen's pathways of the pulp. 10th ed. St. Louis, MO: Mosby Elsevier; 2011.

9. Linn J, Trantor I, Teo N, Thanigaivel R, Goss AN. The differential diagnosis of toothache from other orofacial pains in clinical practice. Aust Dent J. 2007;52:S100-4.

10. Vena DA, Collie D, Wu H, Gibbs JL, Broder HL, Curro FA, et al. Prevalence of persistent pain 3 to 5 years post primary root canal therapy and its impact on oral health-related quality of life: PEARL network findings. J Endod. 2014 Dec;40:1917-21.

11. Nixdorf DR, Law AS, John MT, Sobieh RM, Kohli R, Nguyen RH, et al. Differential diagnoses for persistent pain following root canal treatment: A study in the national dental PBRN. Northwest Dent. 2015 Jul-Aug;94:33-40.

12. Wright EF. Referred craniofacial pain patterns in patients with temporomandibular disorder. J Am Dent Assoc. 2000 Sep;131:1307-15.

13. Fricton J. Critical commentary 1: A unified concept of idiopathic orofacial pain: Clinical features. J Orofac Pain. 1999;Summer;13:185-189.

14. Bossuyt PM, Reitsma JB, Bruns DE, Gatsonis CA, Glasziou PP, Irwig LM, et al. Towards complete and accurate reporting of studies of diagnostic accuracy: The STARD initiative. standards for reporting of diagnostic accuracy. Clin Chem. 2003 Jan;49:1-6.

15. Gutmann JL, Baumgartner JC, Gluskin AH, Hartwell GR, Walton RE. Identify and define all diagnostic terms for periapical/periradicular health and disease states. J Endod. 2009 Dec;35:1658-74.

16. Levin LG, Law AS, Holland GR, Abbott PV, Roda RS. Identify and define all diagnostic terms for pulpal health and disease states. J Endod. 2009 Dec;35:1645-57.

17. Schiffman E, Ohrbach R, Truelove E, Look J, Anderson G, Goulet JP, et al. Diagnostic criteria for temporomandibular disorders (DC/TMD) for clinical and research applications: Recommendations of the International RDC/TMD Consortium Network and Orofacial Pain Special Interest Group. J Oral Facial Pain Headache. 2014 Winter;28:6-27.

18. Durham J, Exley C, John MT, Nixdorf DR. Persistent dentoalveolar pain: The patient's experience. J Orofac Pain. 2013 Winter;27:6-13.

19. Durham J, Nixdorf DR. Healthcare pathway and biopsychosocial impact of persistent dentoalveolar pain disorder: A qualitative study. Int Endod J. 2014 Dec;47:1151-9.

20. Seymour RA, Charlton JE, Phillips ME. An evaluation of dental pain using visual analogue scales and the Mcgill pain questionnaire. J Oral Maxillofac Surg. 1983 Oct;41:643-8.

21. Grushka M, Sessle BJ. Applicability of the McGill pain questionnaire to the differentiation of 'toothache' pain. Pain. 1984 May;19:49-57.

22. Hall EH, Terezhalmy GT, Pelleu GB,Jr. A set of descriptors for the diagnosis of dental pain syndromes. Oral Surg Oral Med Oral Pathol. 1986 Feb;61:153-7.

23. Pau A, Croucher R, Marcenes W, Leung T. Development and validation of a dental pain-screening questionnaire. Pain. 2005 Dec 15;119:75-81.

24. Gonzalez YM, Schiffman E, Gordon SM, Seago B, Truelove EL, Slade G, et al. Development of a brief and effective temporomandibular disorder pain screening questionnaire: Reliability and validity. J Am Dent Assoc. 2011 Oct;142:1183-91.

25. Dworkin SF, LeResche L. Research diagnostic criteria for temporomandibular disorders: Review, criteria, examinations and specifications, critique. J Craniomandib Disord. 1992 Fall;6:301-55.

26. Nixdorf DR, John MT, Wall MM, Fricton JR, Schiffman EL. Psychometric properties of the modified symptom severity index (SSI). J Oral Rehabil. 2010 Jan;37:11-20.

27. Schiffman EL, Ohrbach R, Truelove EL, Tai F, Anderson GC, Pan W, et al. The research diagnostic criteria for temporomandibular disorders. V: Methods used to establish and validate revised axis I diagnostic algorithms. J Orofac Pain. 2010 Winter;24:63-78.

28. Nixdorf DR, Law AS, Look JO, Rindal DB, Durand EU, Kang W, et al. Large-scale clinical endodontic research in the national dental practice-based research network: Study overview and methods. J Endod. 2012 Nov;38:1470-8.

Table 1: Characteristics of the 71 patients enrolled in the study

	Odontogenic pain n=34	**TMD pain n=37**
	Mean (SD) or % (n)	
Age in years	49 (12)	45 (18)
Gender: female	53 (18)	86 (32)
Ethnicity: non-Hispanic	100 (34)	97 (36)
Race: white	79 (27)	92 (34)
Income ≥ $30,000	85 (29)	43 (16)
Dental insurance: yes	94 (32)	81 (30)
Level of education: college degree or more	53 (18)	46 (17)

Table 2:

Diagnostic accuracy measures of the different groups for DePaQ and TMD screener

Diagnostic group	Cell frequencies				Prevalence of the target condition	Sensitivity (CI)	Specificity (CI)	PPV (CI)	NPV (CI)
	True positive	False negative	False positive	True negative					
DePaQ									
AIM 1.0: DePaQ Odontogenic pain versus all TMD pain	29	5	33	4	0.48	0.85 (0.69 to 0.95)	0.11 (0.03 to 0.25)	0.47 (0.34 to 0.60)	0.44 (0.14 to 0.79)
AIM 1.1: DePaQ Odontogenic pain versus TMD pain not referring to teeth only	29	5	22	3	0.58	0.85 (0.69 to 0.95)	0.12 (0.03 to 0.31)	0.57 (0.42 to 0.71)	0.37 (0.09 to 0.75)
AIM 1.2: DePaQ Odontogenic pain versus TMD pain referring to teeth only	29	5	11	1	0.74	0.85 (0.69 to 0.95)	0.08 (0.002 to 0.38)	0.72 (0.56 to 0.85)	0.17 (0.004 to 0.64)
TMD screener									
AIM 2.0: TMD Screener All TMD pain versus Odontogenic pain	34	3	14	20	0.52	0.92 (0.78 to 0.98)	0.59 (0.41 to 0.75)	0.71 (0.56 to 0.83)	0.87 (0.66 to 0.97)
AIM 2.1: TMD Screener TMD pain not referring to teeth only versus Odontogenic pain	23	2	14	20	0.41	0.92 (0.74 to 0.99)	0.59 (0.41 to 0.75)	0.62 (0.45 to 0.77)	0.91 (0.71 to 0.99)
AIM 2.2: TMD Screener TMD pain referring to teeth only versus Odontogenic pain	11	1	14	20	0.26	0.92 (0.61 to 1.00)	0.59 (0.41 to 0.75)	0.44 (0.24 to 0.65)	0.95 (0.76 to 1.00)

PPV: Positive predictive value; NPV: Negative predictive value; CI: Confidence interval=95%

Table 3: Comparison of the sample with other populations

	Nixdorf 2012	Schiffman 2010
	Odontogenic pain n=708	**TMD pain n=141**
	Mean (SD) or % (n)	
Age in years	48 (13)	39 (15)
Gender: female	59	90
Ethnicity: non-Hispanic	96	-
Race: white	91	93
Income ≥ $30,000	84	59*
Level of education: college degree or more	81	81

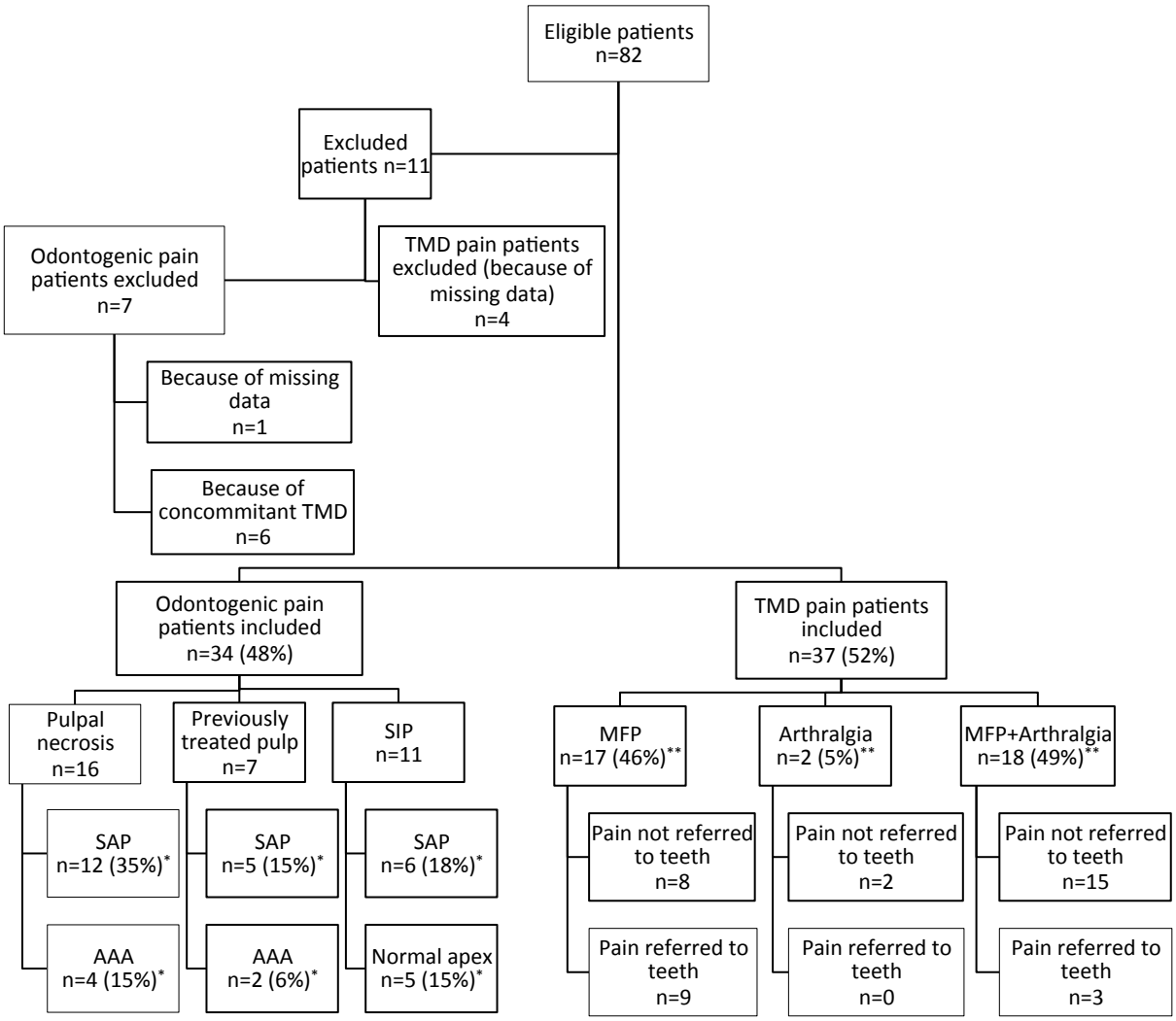
*Income ≥$50,000

Table 4: Item analyses for DePaQ and TMD screener

Question number: topic of the question	***Fischer's coefficient***	***Score in the questionnaire***	***Odontogenic pain***	***TMD pain Not ref. to teeth***	***TMD pain Referring to teeth***
		Min-Max	Mean (SD)		
DePaQ					
Question 1: Location	7.72	0-2	1.3 (0.5)	0.2 (0.5)	1.3 (0.6)
Question 2: Duration	3.79	1-5	2.3 (1)	4.2 (0.9)	4.2 (1.1)
Question 3: Intensity	4.28	1-5	3 (1.2)	3.2 (1.2)	3.2 (1.1)
Question 4: Periodicity	3.79	1-2	1.3 (0.5)	1.4 (0.5)	1.5 (0.5)
Question 5: Radiation	0.64	1-4	2.6 (0.9)	3 (0.9)	2.8 (0.8)
Question 6: Chewing on side	1.13	1-5	4 (1)	3.2 (1.2)	3.4 (1.2)
Question 7: Cold sensitivity	3.34	1-5	3.8 (0.8)	3.4 (0.7)	3.6 (0.9)
Question 8: Gum swelling	0.29	1-5	2 (1.2)	1.2 (0.5)	1.7 (1)
Question 9: Loose tooth	0.23	1-4	1.2 (0.7)	1.1 (0.4)	1.4 (1)
Question 10: Difficulty to swallow	-0.72	1-5	1 (0)	1.2 (0.6)	1.7 (1)
Question 11: Sticking out	0.05	1-5	1.6 (1.1)	1 (0)	1.3 (0.9)
Question 12: Difficulty sleeping	2.72	1-5	2.6 (1.2)	2.3 (1.4)	2.2 (1.3)
Question 13a: Exhausting	0.03	0-1	0.3 (0.5)	0.4 (0.5)	0.7 (0.5)
Question 13b: Electric	-4.44	0-1	0.2 (0.4)	0.1 (0.3)	0.2 (0.4)
Question 13c: Pulling	-5.28	0-1	0.2 (0.4)	0.3 (0.5)	0.3 (0.5)
Question 13d: Numb	4.88	0-1	0.3 (0.5)	0.2 (0.4)	0.3 (0.5)
TMD screener					
Question 1: Pain duration	-	0-2	1.1 (0.8)	1.4 (0.5)	1.3 (0.6)
Question 2: Jaw stiffness	-	0-1	0.3 (0.5)	0.8 (0.4)	0.9 (0.3)
Question 3: Chewing food	-	0-1	0.8 (0.4)	1 (0.2)	1 (0)
Question 4: Opening mouth	-	0-1	0.1 (0.3)	0.9 (0.3)	0.7 (0.4)
Question 5: Clenching	-	0-1	0.4 (0.5)	0.9 (0.3)	0.9 (0.3)
Question 6: Talking	-	0-1	0.1 (0.3)	0.8 (0.4)	0.4 (0.5)

Figures

Figure 1: Patients enrolled



SAP: Symptomatic apical periodontitis, SIP: Symptomatic irreversible pulpitis, AAA: Acute apical abscess, MFP: Myofascial pain.

*Percentage from the Odontogenic pain group only. **Percentage from the TMD pain group only.

Appendix 1: Dental Pain Questionnaire

1. Where in the mouth and/or face region do you feel the pain you currently have? (You may tick more than 1 answer)	1	tooth/teeth (1)	☐
	2	gums (1)	☐
	3	tongue (0)	☐
	4	palate (0)	☐
	5	floor of mouth (0)	☐
	6	inside of cheek (0)	☐
	7	jaw (0)	☐
	8	jaw joint (0)	☐
	9	others (please specify: (0))	☐

2. How long have you had your current pain?	1	less than 1 week (1)	☐
	2	1 week or longer, but less than 4 weeks (2)	☐
	3	4 weeks or longer, but less than 6 months (3)	☐
	4	6 months or longer, but less than 1 year (4)	☐
	5	1 year or longer (5)	☐

3. How would you describe the intensity of your current pain AT ITS WORST?	1	Mild (1)	☐
	2	Discomforting (2)	☐
	3	Distressing (3)	☐
	4	Horrible (4)	☐
	5	Excruciating (5)	☐

4. Thinking about your current pain, how would you describe its pattern of occurrence?	1	Episodic: It comes and goes (1)	☐
	2	Continuous: It's constant (2)	☐

	Not at all (1)	**A small extent (2)**	**Moderate extent (3)**	**A large extent (4)**	**Complete extent (5)**
5. Please indicate the extent to which your pain radiates to the surrounding area:	☐	☐	☐	☐	☐

	Complete extent (5)	**A large extent (4)**	**Moderate extent (3)**	**A small extent (2)**	**Not at all (1)**
6. Please indicate the extent to which it is worse when you chew or eat on the side of your mouth with the pain:	☐	☐	☐	☐	☐

	Makes it a lot more painful (5)	**Makes it a little more painful (4)**	**No effect (3)**	**Makes it a little better (2)**	**Makes it a lot better (1)**
7. Please indicate the effect of eating or drinking something COLD:	☐	☐	☐	☐	☐

Please indicate the extent to which	Not at all (1)	A small extent (2)	Moderate extent (3)	A large extent (4)	Complete extent (5)
8. your gums have been swollen now or have been swollen recently:	☐	☐	☐	☐	☐
9. the tooth where you have the pain from feels loose:	☐	☐	☐	☐	☐
10. it is difficult to swallow now or has been difficult to swallow recently:	☐	☐	☐	☐	☐
11. the tooth where you have the pain from feels like it is sticking out a little:	☐	☐	☐	☐	☐

	Full extent (5)	A large extent (4)	Moderate extent (3)	A small extent (2)	Not at all (1)
12. Please indicate the extent to which you have had difficulties with sleeping:	☐	☐	☐	☐	☐

13. Which of the following word(s), if any, would you use to describe your current pain?	Yes (1)	No (0)
Exhausting	☐	☐
Electric shocks	☐	☐
Pulling	☐	☐
Numb	☐	☐

14. What other word(s), if any, would you use to describe your current pain? Please write in the space below:

The scoring by question is shown in parenthesis behind each response item. Each of the three diagnostic groups have Fisher coefficients associated with each question. To calculate a diagnostic group's score firstly multiply each item response score by the Fisher coefficient for that question and then sum the products across all questions in order to generate a total score for that diagnostic group. This then should be repeated twice

more using the remaining two diagnostic group's relevant Fisher coefficients in order to generate the total scores for the other two diagnostic groups. The diagnostic group with the highest score is the positive group i.e. the result of the screening.

Appendix 2: TMD screener

Question 1. In the last 30 days, on average, how long did any pain last in your jaw or temple area on either side?

a) No pain	**b) From very brief to more than a week but it does stop**	**c) Continuous**
☐	☐	☐

Question 2. In the last 30 days, have you had pain or stiffness in your jaw on awakening?

a) No	**b) Yes**
☐	☐

Questions 3-6. In the last 30 days, did the following activities change any pain (that is, make it better OR make it worse) in your jaw or temple region on either side?

	a) No	**b) Yes**
3. Chewing hard or tough food	☐	☐
4. Opening your mouth or moving your jaw forward or to the side	☐	☐
5. Jaw habits such as holding teeth together, clenching/grinding, or chewing gum	☐	☐
6. Other jaw activities such as talking, kissing, or yawning	☐	☐

Questions 1, 2, and 3 constitute the three-item TMD screener.

Scoring of the questionnaire is 0 for each a) response, 1 for each b) response, and 2 for the lone c) response. The threshold values for a positive score are 2 for the short version and 3 for the long version.